398

VOLUME 80 SEPARATE No. 398

PROCEEDINGS

AMERICAN SOCIETY
OF
CIVIL ENGINEERS

FEBRUARY, 1954

ECONOMIC EFFECT OF IRRIGATION IN A SUBHUMID AREA

by Willis C. Boegli

Presented at
Atlanta Convention
February 15-19, 1954

IRRIGATION AND DRAINAGE
DIVISION

{Discussion open until June 1, 1954}

Copyright 1954 by the AMERICAN SOCIETY OF CIVIL ENGINEERS
Printed in the United States of America

Headquarters of the Society
33 W. 39th St.
New York 18, N. Y.

PRICE $0.50 PER COPY

THIS PAPER

--represents an effort of the Society to deliver technical data direct from the author to the reader with the greatest possible speed. To this end, it has had none of the usual editing required in more formal publication procedures.

Readers are invited to submit discussion applying to current papers. For this paper the final closing dead line appears on the front cover.

Those who are planning papers or discussions for "Proceedings" will expedite Division and Committee action measurably by first studying the printed directions for the preparation of ASCE technical papers. For free copies of these directions—describing style, content, and format—address the Manager, Technical Publications, ASCE.

Reprints from this publication may be made on condition that the full title of paper, name of author, page reference, and date of publication by the Society are given.

The Society is not responsible for any statement made or opinion expressed in its publications.

This paper was published at 1745 S. State Street, Ann Arbor, Mich., by the American Society of Civil Engineers. Editorial and General Offices are at 33 West Thirty-ninth Street, New York 18, N. Y.

ECONOMIC EFFECT OF IRRIGATION IN A SUBHUMID AREA

Willis C. Boegli*

SYNOPSIS

The practice of irrigation originated in the desert climate of Egypt and the Near East; however, it has been a part of man's efforts to increase his food supply regardless of climatic conditions. In the United States, the effect of an irrigation project on the economy of a desert area has been demonstrated in each of the western states. The rapid expansion of individual irrigation systems in the central and eastern states appears indicative of a potential need for project type of developments and raises the question of their effect on the established rural and urban economy of the more humid areas.

This paper reports some of the effects of the W. C. Austin Project, in subhumid southwestern Oklahoma, on the rural and urban economy of the project area as an indication of the effect of similar projects that may be constructed in the more humid areas.

INTRODUCTION

The effect of an irrigation project on the economy of a desert area is fully demonstrated in each of the western states. The rapid expansion of individual irrigation systems in the thirty-one central and eastern states has created an interest in larger project type of developments and their effect on the rural and urban economy of the established economy of the more humid areas.

There is ample historical evidence that irrigation has always been associated with man's efforts to improve his production of food regardless of the climatic environment.

According to the historians Wells[1] and Thorndike,[2] the early man of the eastern Mediterranean area was nomadic, wresting his requirements of food, clothing, and shelter from the plants, animals and physical features of the area through which he traveled. J. H. Breasted,[3] in his history, theorizes that a great drought forced man and the animals of the area into the valleys of the major rivers. Here man learned to domesticate the animals, grow crops, and live in a primitive community. It was in the valleys of the Tigris, Euphrates, and the Nile that he changed from a hunter to a herdsman, from a food gatherer to a food grower and started the processes from which our western civilization evolved. It was here he first learned to use the floodwaters of the rivers to sustain his crops and later to exercise control over the rivers by crude irrigation structures.

* Chf., Allocation and Repayment Branch, Operation and Maintenance Div., U. S. Bureau of Reclamation, Region 5, Amarillo, Texas.

1. H. G. Wells - Outline of History
2. Lynn Thorndike - A Short History of Civilization
3. James Henry Breasted - Ancient Times

In 1950, archeologists of the Universities of Chicago and Pennsylvania[4] found a small clay tablet believed to be 3500 years old near the present city of Baghdad. The tablet has been translated and may be the first agricultural handbook. A father gives his son instructions for growing barley and includes the following admonition: "When you are about to cultivate your field, take care to open the irrigation works (so that) their water does not rise too high (in the field)."

The monuments of Egypt show that Menes, the first King of the first dynasty, expanded the irrigation systems of his day.[5] By 1400 B. C., one-third of the income of the Pharaoh of Egypt was used for the operation and maintenance of irrigation systems. In the days of Joseph, the son of Jacob, "all countries," came to Egypt for food.

From its apparent origin along the Nile, the practice of irrigation spread with the movements of the world's population eastward into India and China and westward toward Europe. The pressure of increasing population on the land forced irrigation into the high rainfall regions of India, Burma, Ceylon, China, Malay, and the islands of the Sea.

The movement of civilization through the Mediterranean area brought irrigation to Greece, Italy, and Spain. In the latter country, the invasion of the Moors in the ninth and tenth century greatly stimulated the use of irrigation, as they brought with them a knowledge of irrigation methods and an appreciation of its value. Irrigation soon became extensively practiced over much of Europe under higher rainfall conditions.

In the western hemisphere, the early history of agriculture is the history of irrigation. The early civilizations of Chile, Peru, Mexico, and the Indian Pueblos of the southwest were based on an irrigated agricultural economy. At the time of the Spanish Conquest, the practice of irrigation was well established, and structures indicate it paralleled the early advancement of mankind.

The Anglo development of irrigation in the United States remained insignificant until 1847 when Brigham Young and his Mormon pioneers diverted a creek to irrigate their gardens and fields on land now occupied by Salt Lake City. You are familiar with the consistent increase in the irrigation development of the west during the past century.

During recent years, individuals and groups of farmers have installed small irrigation systems throughout every State east of the One Hundreth Meridian, and State experiment stations report increased production of many crops. This interest in irrigation is evidenced by an increase from 780,920 acres in 1940 to 1,529,290 acres in 1950[6] in the thirty-one central and eastern states to record a 95.8 percent increase, while irrigation in the so-called irrigation states rose only 21.9 percent. These individual developments are typical of the first irrigation in the West where individual and group action preceded need for project type developments. If there is a correlation, it would seem inevitable that as the practice of so-called supplemental irrigation continues in the East, larger and larger irrigation developments will be in demand. This increasing interest in irrigation is a part of a historical pattern evidenced throughout the world as a part of man's effort to keep his food supply commensurate with his needs.

4. Sumerian Farmers Almanac - Samuel Noah Kramer - Scientific American, November, 1951.
5. Principles of Irrigation - John A. Widtsoe
6. U. S. Department of Commerce, Bureau of Census

As we consider the potential in the increased production of food and fiber in this country from the area east of the One Hundreth Meridian, it is natural to look for some indication of the problems and benefits that would arise from the initiation of a project type of irrigation development. In 1946, the Bureau of Reclamation delivered the first water to the W. C. Austin Irrigation Project in southwestern Oklahoma where the annual precipitation averages about 25 inches.[7] As this area was fully developed in family-sized farms with a related urban economy, before the advent of irrigation, it is being carefully watched for indications of the benefits that will result from project type irrigation in the more humid areas.

The W. C. Austin Multiple-Purpose Project lies in parts of Jackson, Greer, and Kiowa Counties in southwestern Oklahoma. The project provides irrigation, flood control, municipal water, fish and wildlife conservation benefits, and recreational opportunities. Most of the irrigable lands are within a fifteen mile radius of Altus, Oklahoma and are at an elevation between 1250 and 1500 feet.

The evolution to irrigation farming in this area may be typical of others that will follow in the higher rainfall areas.

History of the W. C. Austin Project

Prior to being opened for homesteading in 1897, the area was strictly "cattle country." By 1900, about 51 percent of all the land was in farms averaging 160 acres. Settlement increased rapidly until practically all of the arable land was in cultivation by 1920.

Winter wheat and cotton have been major crops, with a few dairy cows and some poultry on most farms. Beef cattle are often pastured, but the area has generally been devoted to the production of cash crops.

Poor crops, due to drought, and the low crop prices in the early thirties, resulted in a decrease in the rural population. This trend has continued due to farm mechanization and more farm families living in towns. Farm units were too small for the developing type of mechanized farming.

Recurring droughts, and normally low rainfall during a month or two in each growing season, stimulated an interest in irrigation. In 1937, local interest, under the leadership of the late W. C. Austin of Altus, resulted in investigations by several agencies. These efforts were coordinated into the final report by the Bureau of Reclamation, published in 1938 as Senate Document No. 153 of the Third Session of the 75th Congress. Construction was initiated in 1941 by Bureau of Reclamation and W. P. A. forces and completed in 1949 at a cost of about $12,858,000.

Water was first made available to a small acreage of the project in 1946, and farmers irrigated 451 acres, principally cotton. The acreage irrigated increased as the distribution system was extended over the area. In 1949, the system was completed to serve 47,809 acres of irrigable land, and 35,840 acres were irrigated. The project census reports 45,811 acres were irrigated or being prepared for irrigation in 1951.

The project was operated by the Bureau of Reclamation until October 1, 1952, when, in line with long-standing Bureau policy, operation and maintenance was turned over to the water users through the Lugert-Altus Irrigation District. Because of the flood control and other functions involved, the Bureau continues to operate Altus Dam and Reservoir.

7. Sub-humid Areas as defined in "Climate and Man," 1941 Year Book of Agriculture.

Description of Project

The project water supply is obtained from the reservoir formed by Altus Dam and appurtenant works on the North Fork of the Red River. Normal capacity of the reservoir below spillway elevation is 148,640 acre-feet, based on a 1948 survey of sediment encroachment. This has been allocated to silt storage, irrigation storage, and municipal water supply. Storage capacity above the spillway elevation is allocated to flood control.

Altus Dam is a concrete gravity type, partially curved structure. It has granite masonry on the upstream face and on the downstream faces of the non-overflow sections. It rises approximately 100 feet above the stream bed and has a crest length of 1,112 feet. Appurtenant structures consist of Lugert, East, North, and South Dikes, all of which are at low places in the reservoir rim.

The Main Canal, with a capacity of 1,000 cubic feet per second, transports water 4.2 miles from Altus Dam to the northerly boundary of the project's irrigable lands. Approximately 270 miles of canals and laterals have been constructed to serve the 47,809 acres of irrigable lands. In accordance with a contract with the City of Altus, the water supply for that municipality is transported from Altus Reservoir by the project canal system to the municipal reservoirs near the city.

Quartz Mountain State Park, located at the reservoir site, provides boating, fishing, swimming, camping, picnicking and conference facilities for the population within a one hundred mile radius. It has become a very popular recreational facility, and its development has been sharply accelerated by the construction of Altus Reservoir.

Climatic conditions existing on the project and adjacent area are characterized by long, hot summers with short but often severe winters. Extreme recorded temperatures are 120 and -11 degrees Fahrenheit. The growing season averages 224 frost-free days.

Month	1946	1947	1948	1949	1950	1951	1952	1953	40 Yr. Average 1/
January	1.74	.89	.89	4.25	.59	.42	.91	.02	.94
February	.78	.08	2.03	.82	1.53	1.18	.47	.55	.92
March	1.10	.43	1.28	1.02	.01	.91	.99	1.59	1.41
April	.33	3.86	.82	1.80	.78	1.05	4.56	1.69	2.65
May	4.98	7.38	2.29	6.27	2.88	5.11	2.36	.92	3.56
June	2.72	2.98	2.97	10.55	3.73	4.03	.72	1.30	3.42
July	.90	2.16	3.08	.81	8.93	1.87	1.47	2.96	2.05
August	3.74	.53	1.27	2.10	3.18	1.55	.30	2.40	2.27
September	2.46	.52	0	5.40	2.09	1.79	.13	.05	2.68
October	2.57	3.95	1.20	2.94	T	.84	0	4.75	2.90
November	2.05	1.61	.43	0	T	.61	1.36	2/	1.15
December	1.30	1.92	.07	1.04	T	.01	1.33	2/	1.21
Annual Total	24.67	26.31	16.35	37.00	23.72	19.37	14.60		25.16

1/ 1913-52 Average

2/ Not available at time of preparation.

The area has an erratic rainfall pattern which, over the past forty years, has averaged about 25 inches annually. Extremes were 13.9 inches in 1917 to 48.6 inches in 1941. The preceding table shows the monthly precipitation for the past eight years and the 1913-52 average as recorded at the Altus Weather Station located near the center of the project.

A study of the forty year average monthly precipitation shows that the average distribution would be satisfactory for general crop production. However, monthly deviations from the average are extreme, and the need for irrigation to minimize the effect of moisture deficient periods is evident. As indicated in the above table, each of the past eight years had been deficient during a part of the growing season. Three of the eight years were deficient during one month of the growing season; one year was deficient two months; two years, three months, and two years during four months. The need for irrigation is not indicated by the average monthly precipitation but by the frequency and duration of dry periods during the growing season.

The unprecedented drought in the southwest during 1952 and the first half of 1953 caused irrigation water shortages on practically all projects. Carryover storage in the Altus Reservoir provided a near normal supply for 1952 crops, but the supply was only sufficient for one irrigation in 1953. As the rainfall was below average during the growing season, the irrigated and nonirrigated crop production was below average.

The project area is relatively flat with natural drainage courses providing reasonable surface drainage for the area. Irrigable lands are relatively level requiring the minimum in land preparation for irrigation.

Soils on this project are for the most part developed from an alluvial parent material which is underlain by Permian red beds. These soils vary from sandy loams to clay loams with infiltration rates varying from rapid to very slow. Because of many years of continuous cropping, they are generally low in organic matter and available fertility.

Counties in Oklahoma and Texas in this area are relatively small, and, almost without exception, contain one major town which is the site of the county government. These towns are typical urban developments in an agricultural area containing the usual business activities necessary for the processing and shipping of the agricultural products and providing retail trade and services supported by the agricultural population.

The City of Altus, with a 1950 population of 9,548, is located near the center of the project and is the county seat of Jackson County. It is typical of urban developments for this general area.

Effect of the Introduction of Irrigation on Project Farms

It is evident from the past eight years that irrigation has permitted an increase in the higher value crops, increased crop yields, and farm incomes. It increased fixed and annual farm costs, but it has not materially changed tenancy or the size of farms.

The cost of installing a farm irrigation system, including land preparation, is estimated by the Soil Conservation Service to average about $63.00 per acre. This estimate is for complete land leveling and permanent type farm ditches, drops, and turnouts. Few farmers have spent this amount on their leveling and distribution systems.

The trend in farm irrigation layout is away from level irrigation borders toward those with sufficient slope to permit the removal of surplus water that may result from excessive rainfall, excessive deliveries, or both.

Row crops, such as cotton and grain sorghum, are irrigated by running water down shallow furrows between rows. Grains are usually irrigated by use of corrugations, and alfalfa is flooded between borders down a uniform slope. The trend is toward a flexible irrigation system rather than a rigid set of permanent borders.

Increased annual costs due to irrigation include additional seed, commercial fertilizers, and insecticides. Increased tractor and man hours are required for the additional work in deep plowing, more intensive land preparation, cultivation, irrigation, weed control and work connected with harvesting additional production. These increased costs, plus interest on the additional capital investment in land preparation, farm irrigation system and new machinery, constitute the major costs associated with the transition to irrigation farming.

The crop distribution for the non-irrigation lands on, or near, the project follows:

Crop	1944	1945	1946	1947	1948	1949	1950 1/	1951	1952	1953 2/
Grain Sorghum	4.3	4.7	4.5	2.7	3.8	4.1	5.0	5.0	5.0	11.0
Wheat	29.9	44.6	46.6	57.8	69.2	46.8	50.0	35.0	45.0	47.0
Alfalfa Hay	4.6	6.3	8.4	9.8	6.9	4.6	5.0	5.0	5.0	4.5
Cotton	29.7	19.2	21.3	15.7	7.3	25.2	20.0	40.0	30.0	23.0
Other	31.5	25.2	19.2	14.0	12.8	19.3	20.0	15.0	15.0	14.5

1/ U.S.D.A. Cotton Acreage Control Program in effect.

2/ Preliminary Estimates.

The distribution of major irrigated crops expressed as a percent of the irrigable cropland was as follows:

Crop	1947	1948	1949	1950 1/	1951	1952	1953 2/
Wheat	0	17.0	25.6	24.1	5.8	4.4	4.4
Cotton	64.1	43.8	59.6	31.0	68.1	65.6	55.0
Alfalfa Hay	20.8	12.6	8.1	7.7	7.0	9.8	10.0
Grain Sorghum	10.4	19.0	8.7	24.3	8.1	4.6	20.0

1/ U.S.D.A. Cotton Acreage Control Program in effect.

2/ Preliminary Estimates.

The introduction of irrigation appears to have resulted in a reduction in the land planted to wheat, while the acreage of cotton doubled. Alfalfa increased after an early decline and grain sorghum remained about the same, except for 1953 when the irrigation water shortage caused increased plantings. The trend away from wheat is expected to continue as irrigation has not resulted in any material increase in yields. Cotton is expected to remain as a major crop, and alfalfa will be increased to improve soil fertility.

A major factor in the smooth shift to irrigation farming undoubtedly was the fact that crops grown under irrigation were not new to this area. Farmers had the machinery and the production "know-how," and processing and marketing facilities were established so that there was no great disruption of normal farming and marketing practices.

Irrigation permitted a substantial increase in crop yields. The average yields of the four major crops for the past eight years for irrigated and non-irrigated land are shown by the following table:

Year	Cotton		Alfalfa		Grain Sorghum		Wheat	
	Non-Irrig. Bales	Irrigated Bales	Non-Irrig. Tons	Irrigated Tons	Non-Irrig. Bu.	Irrigated Bu.	Non-Irrig. Bu.	Irrig. Bu.
1946	.14	.98	1.1	2.3	11.1	30.5	11.2	1/
1947	.35	.73	1.0	2.0	17.2	27.4	18.9	1/
1948	.43	.87	1.0	2.9	15.9	23.1	20.4	25.2
1949	.62	.78	1.1	2.0	21.2	23.4	12.7	12.8
1950	.55	.70	1.2	1.4	35.0	35.4	12.7	12.7
1951	.25	.61	1.0	2.0	15.0	30.3	12.0	12.4
1952	.17	.65	.7	2.3	5.0	23.3	18.0	22.2
1953 2/	.25	.40	1.0	1.5	12.0	12.0	12.0	12.7
8-Yr Ave.	.34	.71	1.0	2.0	16.4	25.5	14.7	16.3

1/ No wheat irrigated.
2/ Preliminary estimates.

The above table indicates the favorable conditions that existed for non-irrigated crops in 1949 and 1950, compared to the other six years, and the adverse effect of the 1953 irrigation water shortage.

If it is assumed that the increase in crop production by irrigation during the past eight years is indicative of the future, we may expect it to double the yields of cotton and alfalfa, increase the yield of grain sorghums at least 50 percent and create no appreciable increase in the yield of wheat.

Progressive farmers have produced yields well above the project average by rotations with alfalfa, commercial fertilizers and careful use of irrigation water. With improved practices, the average cotton yield should exceed a bale per acre; grain sorghum should produce between 40 and 50 bushels per acre, while alfalfa hay should approach four tons per acre.

The Oklahoma Agricultural Experiment Station, in mimeographed Circular M-241, "Cotton Variety Test Results 1952," reports the following irrigated cotton yields on the Altus Station:

Variety	Lint Per Acre	Staple in 32's	Fertilizers	Insect Control
	Bales			
Highest Yielding CR-2	2.39	31	100# 16-20-0 Side Dressing 60# N	5 Sprays
Lowest Yielding Empire	1.84	35	100# 16-20-0 Side Dressing 60# N	5 Sprays
Average 16 Varieties	2.17	33	100# 16-20-0 Side Dressing 60# N	5 Sprays

Average yields of varities tested on three non-irrigated stations near the project averaged .24 bales of lint per acre in 1952, while the average yield on the irrigated Altus Station was 2.17 bales. This indicates the spectacular possibilities of irrigation in southwestern Oklahoma during dry years.

Soil Conservation Service records show nine project farmers have produced over two bales of cotton per acre on field basis. Without exception, these fields have been in alfalfa prior to the cotton. Other yields approaching two bales have been secured with nitrogen and phosphate fertilizers.

Of the new crops introduced, early Irish potatoes have been tried over several years and show promise. Lettuce of good quality was grown in 1952. Castor beans, with good management, and at present support prices, are profitable, although the gross returns are only about half that of cotton. Alfalfa seed will continue to be harvested each year from a large part of the alfalfa acreage. Irrigation permits the use of many new crops impossible to grow under normal rainfall conditions. The use of these crops is dependent upon economic factors and not limited by soil moisture.

Improvement in farming practices on non-irrigated land has been slow, as the fluctuation in rainfall prevents them from being uniformly effective and often renders them unprofitable. There is nothing to indicate an increase in the production of non-irrigated crops due to improved farm practices during the past few years. Increase in production on the project has been due to the use of irrigation and associated cultural practices. As there is no indication that an increase in crop yields would have occurred without irrigation, it is assumed that most of the increased production under irrigation was due to irrigation water and the improved farm practices that it has encouraged.

Many farmers first considered irrigation an insurance against drought and intended to use it only when required in connection with normal dry farming practices. Experience to this time has resulted in a conclusion that to be successful there must be a complete transition to irrigation farming involving the use of rotation with legumes, increased use of commercial fertilizers, adapted varieties of crops, an increase in plant population, improved insect and weed control measures, and generally a more intensified type of farming.

The trend to these practices is slow, but Department of Agriculture and State College personnel believe farmers are now aware of the need for a more intensive type of farming and are making definite efforts to improve their irrigation farming practices.

Average per acre gross crop value for the irrigated and comparable non-irrigated lands as computed from project census data and estimates of agency representatives are as follows:

Year	Average Gross Crop Value		
	Irrigated 1/	Non-Irrigated 2/	Average Value of Irrigated over Non-Irrigated
	Dollars	Dollars	Dollars
1946	130.72	22.07	108.65
1947	105.34	43.86	61.48
1948	89.41	39.13	50.28
1949	85.16	28.25	56.91
1950	73.86	34.51	39.35
1951	110.93	53.63	57.30
1952	123.80	33.04	90.76
1953 3/	55.99	29.11	26.88

1/ Average per acre gross crop value from Bureau of Reclamation project census.

2/ Average per acre gross crop value for years 1946 through 1949 based on census of non-irrigated project land, 1950 through 1952 based on estimates of crop distribution and average yields by U.S.D.A. and State College representatives.

3/ Preliminary estimate.

The following table shows the increase in gross crop value due to irrigation:

Year	Acres Irrigated 1/	Increase in Per Acre Gross Crop Value With Irrigation	Increase in Income Due to Irrigation
1946	451	$108.65	$ 49,000
1947	3273	61.48	201,200
1948	17433	50.28	876,500
1949	35840	56.91	2,039,600
1950	45952	39.35	1,808,200
1951	45811	57.30	2,624,900
1952	43735	90.76	3,969,400
1953 2/	43000	26.88	1,155,800
Total & Average	- -	54.03	$12,724,600

1/ Acreage in irrigation rotation used to compute gross crop value.

2/ Preliminary estimate.

The value of crops produced with irrigation over that which would have been produced by dry farming results from an increase in the acreage of high value crops, and an increase in the average yield per acre, both made possible by supplemental water. The estimated increased value of crops of $12,724,000 on the project since the advent of irrigation is a major stimulating factor in the economy of the trade area.

Effect of the Project on the Economy of the Trade Area

In order to evaluate the effect of the project on the economy of Jackson County, it was compared with the four adjacent Oklahoma counties of Harmon, Greer, Kiowa, and Tillman. The county seats of these four counties all lie within a radius of fifty miles of the project. Climatic conditions are practically identical.

Each county has one major town which is the location of the County Government. These towns provide processing and shipping facilities for the adjacent agricultural production and the goods and services required by the farm population. Most of the counties contain a few small rural communities.

The economic characteristics of the counties and their respective county seats were carefully studied and found to be a reasonable delineation of trade areas and comparable in basic resources.[8] The economy of the two adjoining Texas Counties is so heavily influenced by major rail and highway transportation, oil activities, and basic manufacturing that they are not comparable.

In evaluating the economic factors, the percent of change since 1940 was used rather than a numerical evaluation. This method eliminates the influence of size in the comparison of economic factors.

The accuracy of the analyses depends upon the accuracy of the basic assumption; namely, that without the Project, the economy of Jackson County would have increased in the same proportion as the actual increase in the four adjacent counties. This seems a reasonable assumption, and it is the best basis for analyses currently available, but the actual "without" project condition in Jackson County may be more or less favorable than here assumed. The benefits of the project, therefore, are not claimed to be precise evaluations, but a reasonable indication of the impact of the project on the trade area.

The effect of the W. C. Austin Project on Jackson County as indicated by an analysis of census and other data[9] is summarized as follows:

Economic Factors	Percent Change 1940 - 1950		
	Comparable Counties	Jackson County	Jackson Over Other Counties
Population	- 17.3	- 11.5	5.8
Employed workers	2.0	10.2	8.2
Agricultural workers	- 15.8	- 10.1	5.7
Railroad & Railway Express workers	1.1	15.5	14.4
Total Retail Sales 1/	287.0	379.2	92.2
Per Capita Retail Trade 1/	378.0	463.7	85.7

1/ 1939-51 period.

8. Details of this study contained in report "Effect of the Introduction of Irrigation on Rural and Urban Economy of a Subhumid Area," Bureau of Reclamation, Region 5, Amarillo, Texas.
9. U. S. Census, Rand McNally, and Bureau of Business Research, University of Oklahoma.

Expressed in terms of population and dollars, the project appears to have been responsible for the following:

Economic Factors		Increase or Retention Due to Project
Population	1940 - 1950	1300
Employed workers	1940 - 1950	488
Agricultural workers	1940 - 1950	145 1/
Railroad workers	1940 - 1950	14
Retail trade in	1951	$ 3,975,000
Retail trade in	1952	$ 5,900,000
Total trade created	1952	$14,209,000

1/ Data for April conditions and does not include seasonal harvest workers.

It must be recognized that during the period of construction and first few years of project operation, the area had good non-irrigated crops with good prices. Increased crop production due to the Project was small in 1949 and 1950, and not until 1951 and 1952 did a large increase in crops result from irrigation. The major benefit from the project shown by a comparison of the 1940 and 1950 census data is, therefore, due to the partial development of the Project, residual effect of construction expenditures, and the stimulating and stabilizing effect of the Project's potential value on the economy of the county.

Using the procedure developed by Mr. Martz[10] in the Payette, Idaho, study, the following benefits were created by the project in 1952:

Direct Farm Benefits (Net farm income plus farm wages)	$3,135,000
Indirect local non-farm benefits (Increased non-farm net income)	$3,175,000
Total Local Benefits	$6,310,000

The monetary evaluation did not measure the effect of the project on the county tax base, the increase in federal income taxes, or the value of the stability added to the project farms and the trade area.

The evaluation of the effect of the project on the town of Altus, like that presented for Jackson County, is based on secondary data[11] and the assumption that without the W. C. Austin Project it would have changed in the same manner as the average of the county seats of the four adjoining counties. The following is a summary of the percent gains in business activities between 1940 and 1952 in Altus and four comparable towns, and the percent by which Altus exceeded the average of the four other towns because of the W. C. Austin Project:

10. "An Experiment in the Measurement of the Indirect Benefits of Irrigation," Payette, Idaho, Bureau of Reclamation, Region 1, Boise, Idaho, 1950.
11. Bureau of Business Research, University of Oklahoma, U. S. Census and Rand McNally.

Economic Factor	Percent Increase 1940 - 1952		
	Altus	Ave. Four Comparable Towns	Difference
Population 1/	13.3	5.8	7.5
Retail Sales	407.	332.	75.
Per Capita Retail Sales	338.	303.	35.
Bank Deposits	540.	379.	161.

1/ Based on 1940 and 1950 census data.

Expressed in population and dollar value, the increase in urban economic activities due to the project, is as follows:

Economic Factor	Increase Due to Project
Population - 1940-1950	645
Retail Sales in 1952	$ 2,484,000
Bank Deposits in 1952	$ 3,050,000

The above estimates of increased business activities are indicative of the impact of the project on the urban economy and is a part of that estimated for Jackson County. There is no evaluation of the effect of the project on the city tax base or the stability it provides for business enterprises.

Problems in Subhumid Irrigation

The eight years of irrigation indicate some problems that may occur on new projects in the more humid areas. These include problems in soil fertility, drainage, irrigation practices, and operation and maintenance of the project works.

The low fertility level of project soils has resulted in crop yields that appear low compared to other irrigated areas. With the use of irrigation, soil fertility--not soil moisture--became the limiting factor in the production of crops. Land that had been dry farmed for over thirty years without apparent serious plant food deficiencies did not respond to irrigation.

Crop yields under irrigation have been greatly increased by the use of nitrogen and phosphate fertilizers, and rotation with alfalfa. It is increasingly evident that irrigation requires more farm management than merely application of irrigation water during drought periods. It requires a new approach to farming in which an intensive use of rotations with legumes or green manure crops, commercial fertilizers, and improved farming practices will pay off in greatly increased yields.

Although the project area is quite well drained by natural drainage courses, damage from excessive water does occur during periods of high and continued rainfall. The introduction of irrigation did not materially change this situation, except as heavy rains occur while irrigation water is being delivered through the system. At such times, the distribution system must be emptied by use of wasteways to prevent damage to the canals.

Some farm irrigation systems with level borders were installed early in the project's history. Heavy rains in 1949 proved these systems unsatisfactory on slowly permeable lands, as water was held in the borders by continuing rains long enough to damage or destroy the crops. Irrigation borders now being constructed have some lineal slope, and all have an outlet.

The need for adequate subsurface drainage, long recognized in the west, is an ever present need in the subhumid area. Surface drainage for project land, as well as control of seepage, must be provided.

A new irrigation project in the west attracts many farmers from nearby irrigated areas who bring with them valuable experience in irrigation farming. This does not happen in the same degree when irrigation is brought to farms that have been operated for many years. A few experienced irrigation farmers moved on the project, and several landowners who did not wish to irrigate sold their land. Increased farming costs will force some farmers from the project, while those willing to increase their management input will make increased profits.

One detrimental factor in the proper use of irrigation water was the long established practice of waiting for rain. During the first few years of the project, farmers would wait for rain until crops were damaged before ordering irrigation water. The proper timing of irrigation has been rendered more difficult due to the occasional rains occurring during the irrigation season and the impossibility of determining if the rain will be an inefficient, light shower, or a five inch deluge.

Data on the irrigation water requirements of the W. C. Austin Project provides only a general guide to requirements in other subhumid areas. Actual irrigation water requirements have not yet been established as the optimum use of irrigation has not been reached. It is evident from project data that there is a greater inefficiency of total precipitation and irrigation deliveries in the subhumid area than on the usual desert type of project. A rain that falls on a field just following its irrigation may be ineffective or even detrimental.

Operation of the W. C. Austin Project presents some unparalleled problems in delivery of irrigation water. Preplanting irrigation usually starts early in March and continues steadily, or intermittently, as rainfall varies through the spring months. It is during this period that irrigation operators have difficulty in ordering water. Hot days may increase irrigation demands toward full capacity of the distribution system, and in the course of a few hours, localized storms may dump huge quantities of water and debris in canals and laterals. This condition requires the project operating staff to be dispersed to strategic wasteway structures to dispose of the excess water and protect the irrigation works. As irrigation demands will immediately slack off due to the rain, the balance of the irrigation water in the canals and laterals must be turned down the wasteways and hence lost as a source of beneficial use.

As may be expected, maintenance of canals, laterals, drains and wasteways throughout the long irrigation season is of utmost importance where sufficient rainfall occurs and intermittent water deliveries promote luxuriant weed growth. Clogging of these channels disrupts, and often makes impossible, the efficient delivery of water. In this area, weeds of many kinds, often requiring different chemicals to control, aggressively encroach on the canal sides and bottom. Due to the long seasonal requirements for irrigation, expensive chemical control is required, as mechanical methods are impractical in flowing canals.

There is a need for the development of sod forming grasses that will prevent the erosion of canal banks and discourage heavy weed growth. Consideration should always be given to the installation of underground distribution systems to reduce operation and maintenance costs. The comparative cost of an enclosed system, savings in operation and maintenance expenditures, and the payment capacity of water users should be evaluated.

SUMMARY

Although the practice of irrigation originated in the arid sections of Egypt in the Near East, it has been one means of increasing the production of food and fiber to meet man's requirements regardless of climatic conditions. The increasing interest in irrigation farming in the higher rainfall areas of the United States is typical of the developments throughout the world.

The construction and development of the W. C. Austin Project in Oklahoma, in an area that receives an average annual precipitation of about twenty-five inches, provides some indication of the benefits and problems to be expected in similar projects in the more humid areas.

Conversion to irrigation farming on the W. C. Austin Project has been rapid. The size of farms, farm tenure and the crops grown have changed but little with the introduction of irrigation. Major changes have been an increase in the acreage of higher value crops and an increase in the average production per acre.

During eight years, irrigation has more than doubled the average per acre value of crops, and during years of below average precipitation, such as 1952, the value of irrigated crops was almost four times that of comparable non-irrigated lands. In 1952, the project increased the value of crops produced by almost $4,000,000, which may be near the average to be expected for the future. Direct farm benefits for 1952 (net farm income plus farm wages) are estimated at $3,135,000 or 79 percent of the increase in crop value due to the project. These benefits of irrigation were achieved without the problems of settlements and "pioneering" that have been common to western desert projects.

Irrigation offers emancipation from one-crop farming, permitting shifts in crops to meet changing demands. Crop adaptability is increased, and multiple cropping is made possible through the control of soil moisture.

Available secondary data permits an evaluation of the effect of the project on some of the economic factors of the trade area. Irrigation increased the population, employment, and trade in the county based on a comparison with adjoining counties. Increase in total sales in 1952 due to the project was estimated at $15,000,000, of which $5,900,000 was retail trade.

Based on the procedure developed by M. E. Martz for Payette, Idaho, the local direct (farm) benefits of the project in 1952 would be about $3,135,000, and the local indirect (non-farm) benefits would be $2,976,000 for total benefits in 1952 of $6,111,000.

Major problems encountered during the first few years of irrigation farming on the W. C. Austin Project appear to be nearing solution. Project lands, dry farmed for many years, were low in fertility and did not respond well to irrigation without commercial fertilizers or rotation with legumes. Farmers are learning that irrigation farming requires a complete new approach to farm management involving a greater input of labor and capital and a more intensive use of land.

Occasional heavy rains during the irrigation season require land preparation with surface drainage on the heavier soils. Surface drainage over the entire project must be provided, as well as adequate control of seepage.

Operation and maintenance of the project distribution systems involves greater weed control expenditures than are normal for western desert projects due to the long growing season and the intermittent use of canals.

The increase in irrigation in the subhumid and humid areas of this nation is a part of a world-wide pattern of man's efforts to meet his food needs. Continued interest in irrigation appears certain with eventual need for project type developments. The benefits of irrigation projects in this area may be less spectacular than those in the deserts, but their impact on the economy is none the less real. Although typical of only a part of the great subhumid and humid sections of the nation, the W. C. Austin Project has demonstrated the increased production that results from irrigation and its beneficial effect on the rural and urban economy.

ACKNOWLEDGMENT

The author is indebted to the Jackson County, Oklahoma representatives of the Soil Conservation Service, and Farmers Home Administration; County Agricultural Extension Agent and Associate Extension Agent, (Irrigation Specialist); Representatives of the Chambers of Commerce of Altus, Fredrick, Mangum, Hollis, and Hobart, Oklahoma; Manager of the Lugert-Altus Irrigation District; Bureau of Business Research, University of Oklahoma, and employees of the Bureau of Reclamation for information, review, and helpful comments.

PROCEEDINGS-SEPARATES

The technical papers published in the past twelve months are presented below. Technical-division sponsorship is indicated by an abbreviation at the end of each Separate Number, the symbols referring to: Air Transport (AT), City Planning (CP), Construction (CO), Engineering Mechanics (EM), Highway (HW), Hydraulics (HY), Irrigation and Drainage (IR), Power (PO), Sanitary Engineering (SA), Soil Mechanics and Foundations (SM), Structural (ST), Surveying and Mapping (SU), and Waterways (WW) divisions. For titles and order coupons, refer to the appropriate issue of "Civil Engineering" or write for a cumulative price list.

VOLUME 79 (1953)

FEBRUARY: 169(HY), 170(ST), 171(CP), 172(SU) & (AT), 173(SU) & (AT), 174(SU) & (AT), 175(HY), D-121(HW), D-127(ST).

MARCH: 176(SA), 177(EM), 178(HY), 179(EM), 180(HY), D-123(HY), D-126(ST), D-128(ST).

APRIL: 181(WW), 182(ST), 184(HY), 185(EM), 186(HY), 187(ST), 188(HY), D-135(HY), D-136(ST).

MAY: 189(HY), 190(HY), 191(CP) & (AT), 192(SM), 193(HY), D-129(PO), D-138(CP), D-145(ST).

JUNE: 194(CP) & (AT), 195(SM), 196(CP) & (AT), 197(HY), 198(ST), 199(EM), D-134(HY), D-141(HY).

JULY: [a] 200(SM)[b], 201(ST)[b], 202(EM)[b], 203(SM)[b], 204(AT)[b], 205(EM)[b], 206(ST)[b], 207(SA)[b], 208(SA)[b], 209(ST)[b], 210(SU)[b], 211(EM)[b], 212(SU)[b], 213(IR)[b], 214(HW)[b], 215(SM)[b], 216(ST)[b], 217(ST)[b], 218(ST)[b], 219(ST)[b], 220(SM)[b], 221(HW)[b], 222(SM)[b], 223(EM)[b], 224(EM)[b], 225(EM)[b], 226(CO)[b], 227(SM)[b], 228(SM)[b], 229(IR)[b].

AUGUST: 230(HY), 231(SA), 232(SA), 233(AT), 234(HW), 235(HW), 237(AT), 238(WW), 239(SA), 240(IR), 241(AT), 242(IR), 243(ST), 244(ST), 245(ST), 246(ST), 247(SA), 248(SA), 249(ST), 250(EM)[c], 251(ST), 252(SA), 253(AT), 254(HY), 255(AT), 256(ST), 257(SA), 258(EM), 259(WW).

SEPTEMBER: 260(AT), 261(EM), 262(SM), 263(ST), 264(WW), 265(ST), 266(ST), 267(SA), 268(CO), 269(CO), 270(CO), 271(SU), 272(SA), 273(PO), 274(HY), 275(WW), 276(HW), 277(SU), 278(SU), 279(SA), 280(IR), 281(EM), 282(SU), 283(SA), 284(SU), 285(CP), 286(EM), 287(EM), 288(SA), 289(CO).

OCTOBER: [d] 290(all Divs), 291(ST)[c], 292(EM)[c], 293(ST)[c], 294(PO)[c], 295(HY)[c], 296(EM)[c], 297(HY)[c], 298(ST)[c], 299(EM)[c], 300(EM)[c], 301(SA)[c], 302(SA)[c], 303(SA)[c], 304(CO)[c], 305(SU)[c], 306(ST)[c], 307(SA)[c], 308(PO)[c], 309(SA)[c], 310(SA)[c], 311(SM)[c], 312(SA)[c], 313(ST)[c], 314(SA)[c], 315(SM)[c], 316(AT), 317(AT), 318(WW), 319(IR), 320(HW).

NOVEMBER: 321(ST), 322(ST), 323(SM), 324(SM), 325(SM), 326(SM), 327(SM), 328(SM), 329(HW), 330(EM)[c], 331(EM)[c], 332(EM)[c], 333(EM)[e], 334(EM), 335(SA), 336(SA), 337(SA), 338(SA), 339(SA), 340(SA), 341(SA), 342(CO), 343(ST), 344(ST), 345(ST), 346(IR), 347(IR), 348(CO), 349(SM), 350(HW), 351(HW), 352(SA), 353(SU), 354(HY), 355(PO), 356(CO), 357(HW), 358(HY).

DECEMBER: 359(AT), 360(SM), 361(HY), 362(HY), 363(SM), 364(HY), 365(HY), 366(HY), 367(SU)[e], 368(WW)[e], 369(IR), 370(AT)[e], 371(SM)[e], 372(CO)[e], 373(ST)[e], 374(EM)[e], 375(EM), 376(EM), 377(SA)[e], 378(PO)[e].

VOLUME 80 (1954)

JANUARY: 379(SM)[e], 380(HY), 381(HY), 382(HY), 383(HY), 384(HY)[e], 385(SM), 386(SM), 387(EM), 388(SA), 389(SU)[e], 390(HY), 391(IR)[e], 392(SA), 393(SU), 394(AT), 395(SA)[e], 396(EM)[e], 397(ST)[e].

FEBRUARY: 398(IR)[f], 399(SA)[f], 400(CO)[f], 401(SM)[f], 402(AT)[f], 403(AT)[f], 404(IR)[f], 405(PO)[f], 406(AT)[f], 407(SU)[f], 408(SU)[f], 409(WW)[f], 410(AT)[f], 411(SA)[f], 412(PO)[f], 413(HY)[f].

---

a. Beginning with "Proceedings-Separate No. 200," published in July, 1953, the papers were printed by the photo-offset method.
b. Presented at the Miami Beach (Fla.) Convention of the Society in June, 1953.
c. Presented at the New York (N.Y.) Convention of the Society in October, 1953.
d. Beginning with "Proceedings-Separate No. 290," published in October, 1953, an automatic distribution of papers was inaugurated, as outlined in "Civil Engineering," June, 1953, page 66.
e. Discussion of several papers, grouped by divisions.
f. Presented at the Atlanta (Ga.) Convention of the Society in February, 1954.

AMERICAN SOCIETY OF CIVIL ENGINEERS

OFFICERS FOR 1954

PRESIDENT

DANIEL VOIERS TERRELL

VICE-PRESIDENTS

Term expires October, 1954:
EDMUND FRIEDMAN
G. BROOKS EARNEST

Term expires October, 1955:
ENOCH R. NEEDLES
MASON G. LOCKWOOD

DIRECTORS

Term expires October, 1954:
WALTER D. BINGER
FRANK A. MARSTON
GEORGE W. McALPIN
JAMES A. HIGGS
I. C. STEELE
WARREN W. PARKS

Term expires October, 1955:
CHARLES B. MOLINEAUX
MERCEL J. SHELTON
A. A. K. BOOTH
CARL G. PAULSEN
LLOYD D. KNAPP
GLENN W. HOLCOMB
FRANCIS M. DAWSON

Term expires October, 1956:
WILLIAM S. LaLONDE, JR.
OLIVER W. HARTWELL
THOMAS C. SHEDD
SAMUEL B. MORRIS
ERNEST W. CARLTON
RAYMOND F. DAWSON

PAST-PRESIDENTS

Members of the Board

CARLTON S. PROCTOR
WALTER L. HUBER

TREASURER

CHARLES E. TROUT

EXECUTIVE SECRETARY

WILLIAM N. CAREY

ASSISTANT TREASURER

GEORGE W. BURPEE

ASSISTANT SECRETARY

E. L. CHANDLER

PROCEEDINGS OF THE SOCIETY

HAROLD T. LARSEN
Manager of Technical Publications

DEFOREST A. MATTESON, JR.
Editor of Technical Publications

PAUL A. PARISI
Assoc. Editor of Technical Publications

COMMITTEE ON PUBLICATIONS

FRANK A. MARSTON, *Chairman*

I. C. STEELE
GLENN W. HOLCOMB
ERNEST W. CARLTON
OLIVER W. HARTWELL
SAMUEL B. MORRIS